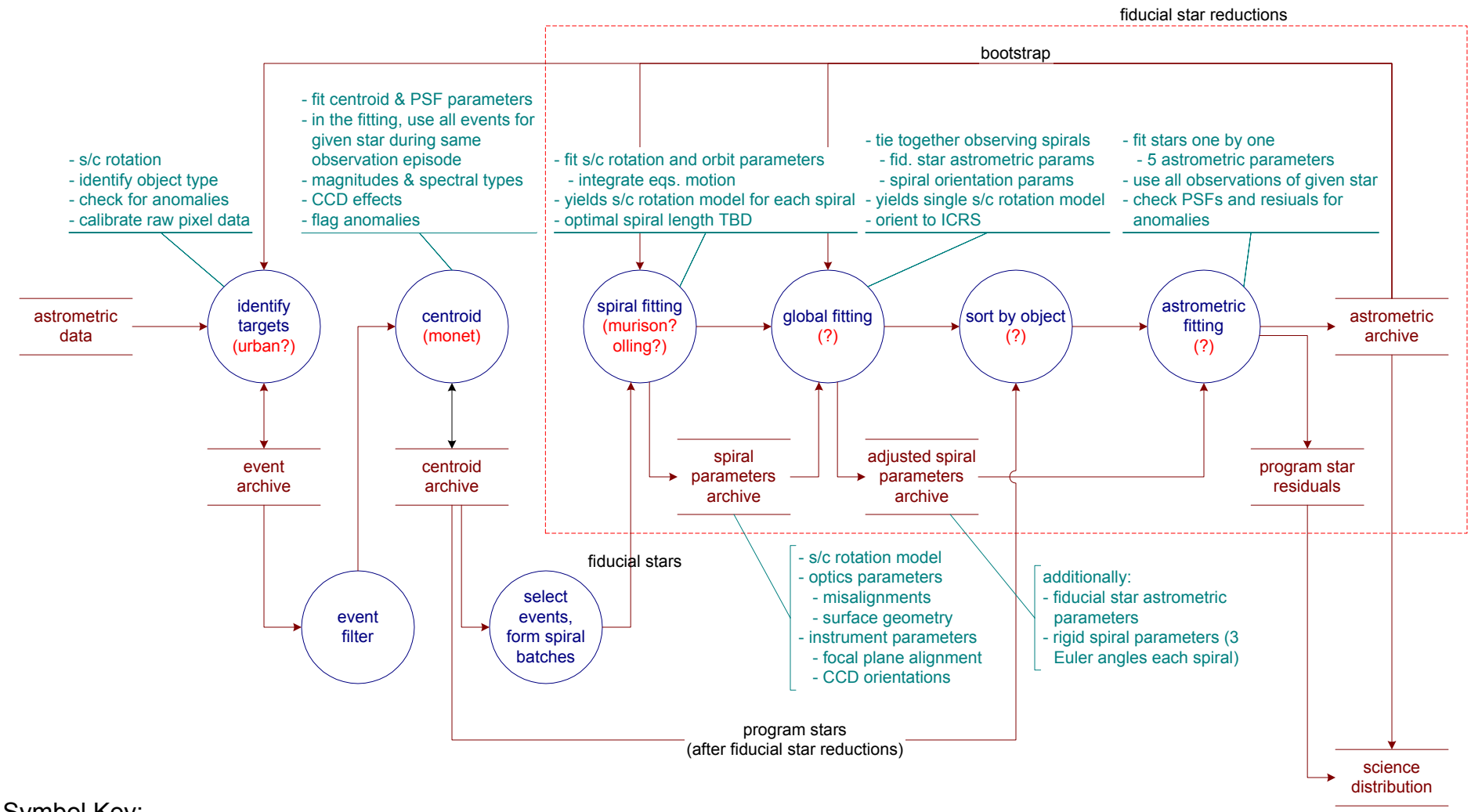
FAME Data Reduction Overview: Astrometric Pipeline

12 September, 2000



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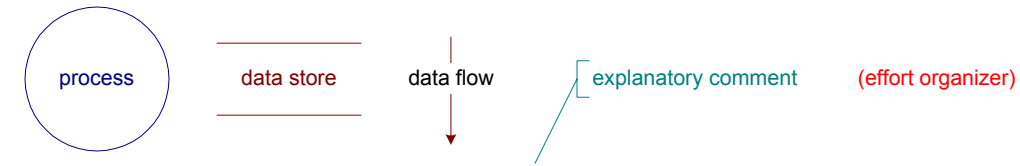

Identify Targets

- Objective: use target catalog and knowledge of spacecraft rotation to identify targets.
- Tasks:
  - Calibrate raw pixel data.
    - known CCD effects (e.g., variations in pixel sensitivity, etc.)
  - Identify type of object.
  - Check for anomalies.

Centroid

- Objective: determine centroid & PSF parameters for targets.
- Task: using all events for a given star during the same observation episode (the time during which a given star is in the field of view on successive rotations of the s/c), do weighted least squares (WLS) fit of the centroid and PSF parameters for each star.
- WLS parameters
  - centroid model(s)
  - PSF model(s)
  - stellar parameters (spectral type, magnitude)
  - CCD
  - star multiplicity analysis
- Calculate residuals.
- Flag anomalies.
- Photometric fitting.

Spiral Fitting

- Objective: a rigid spiral
  - Uncertainty in angular separations is small compared to single-measurement uncertainty.
- Yield: spacecraft rotation model for each spiral segment.
- Task: perform weighted least squares fit of the spacecraft orbit and spin dynamics and instrument parameters.
  - Integrate equations of motion.
  - Integrate variational equations.
  - Use *a priori* fiducial star coords, then bootstrap.
- WLS parameters: see Spin Dynamics
- Optimal spiral segment length TBD.
- Spiral segment orientation not well known (but that's okay for now).

Global Fitting

- Objective: tie the spiral segment rotation models together.
- Yield: a single spacecraft rotation model.
- Task: weighted least squares fit of fiducial stars (or subset of fiducial stars).
- WLS parameters
  - Fiducial star astrometric parameters
  - Spiral segment orientation parameters
- Toss out (and replace) anomalous stars.
- Check: repeat for different sets of fiducial stars.
- Inertial fram orientation.

Astrometric Fitting

- Objective: determine astrometric parameters for each target star
- Yield:
  - astrometric parameters
  - residuals
    - Look for peculiar motions (planets!)
- Tasks:
  - Weighted least squares fit
    - Do one star at a time.
    - Use all observations (i.e., data span is mission length).
  - Check PSFs for anomalies
    - asymmetry
    - color variations
    - size variations
  - Identify "interesting" stars (anomalous residuals).
  - Search residuals of "interesting" stars for periodicities.

Spin Dynamics Issues (1 of 4)

- Stochastic and other Hard-to-Model Perturbations
  - Fuel sloshing
  - Variability of solar irradiance
    - variations on all timescales
    - short-term fluctuations are stochastic
    - variation ~0.1 percent over long timescales
    - variation ~0.01 percent over short timescales
  - Earth radiation pressure
    - visible
    - infrared
    - variability due to weather
    - complicated torques
      - spacecraft not protected by shield
      - optical ports
      - AKM hole
  - Nutation damping mechanism stiction and/or other undesirable behaviors
  - Magnetic torques near magnetopause

Spin Dynamics Issues (2 of 4)

- Solar Shield
  - Shield (panels, teflon tape, & webbing) & flattop albedos
    - variable over time as materials age
    - spatial inhomogeneities
    - AKM: hole or cover?
  - Variations in effective shield angle
    - nonuniform in circumference
    - slow variation over time
    - fast variation — flapping modes (eclipses)
  - Shield geometry perturbations
    - solar panels
      - potato chipping
      - dynamic modes
        - radial (flapping)
        - twisting
        - what are the timescales for damping?
    - interpanel membranes
      - sagging
      - flapping?

Spin Dynamics Issues (3 of 4)

  - Thermal radiation torques
  - Axis of shield misaligned with spacecraft spin axis
  - Trim tab problems
    - nonuniform axis directions
    - mechanism slop?

- Perturbations Due to Events
  - Eclipses
  - Geotail particle bursts
    - "wind" gusts
    - potentials across spacecraft surfaces cause electrical currents which cause magnetic torques
      - caused Echo spinup
    - very large bursts from fast CME events
      - a few times per year around solar max
      - potential for spacecraft damage?
  - Magnetopause crossings
    - relatively rare at geosynch (a few times a year)
    - short duration (~15 min) exposure to full blast of the solar wind
  - Micrometeoroid hits

Spin Dynamics Issues (4 of 4)

- Other Smooth Perturbations
  - Spin axis not aligned with principal axis
  - Spacecraft thermal radiation torques
    - Sun shield
    - thermal radiators
    - telescope viewports
  - Gravity gradient torques
  - Movement of center of gravity as fuel is expended
  - Variations of Sun direction due to Sun-tracking dynamics
  - Variation of solar radiation pressure as spacecraft orbits around the Earth
  - Magnetic torques
  - Lunar torques
  - Jitter

FAME Simulation Overview

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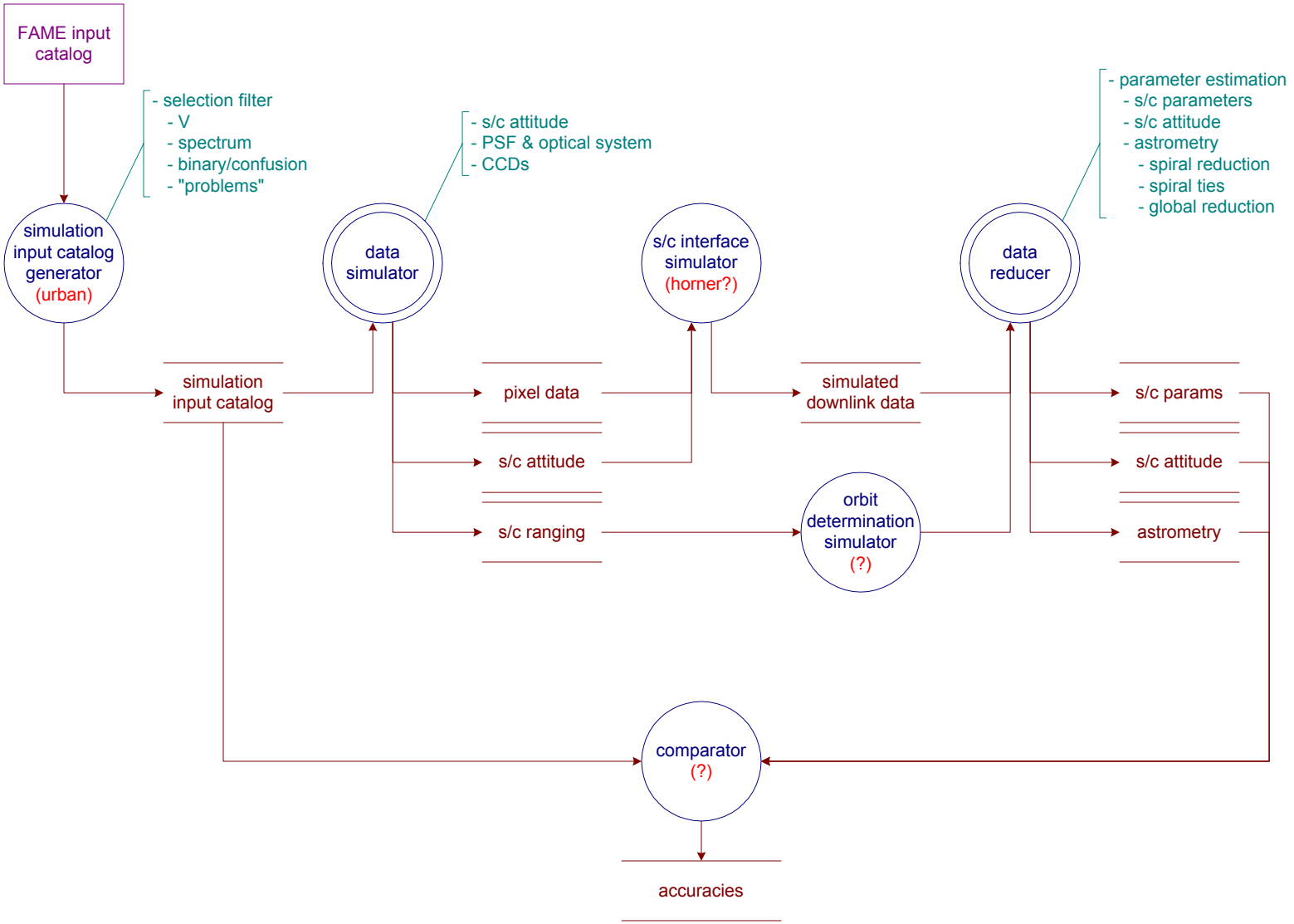

Symbol Key:

FAME Data Simulator

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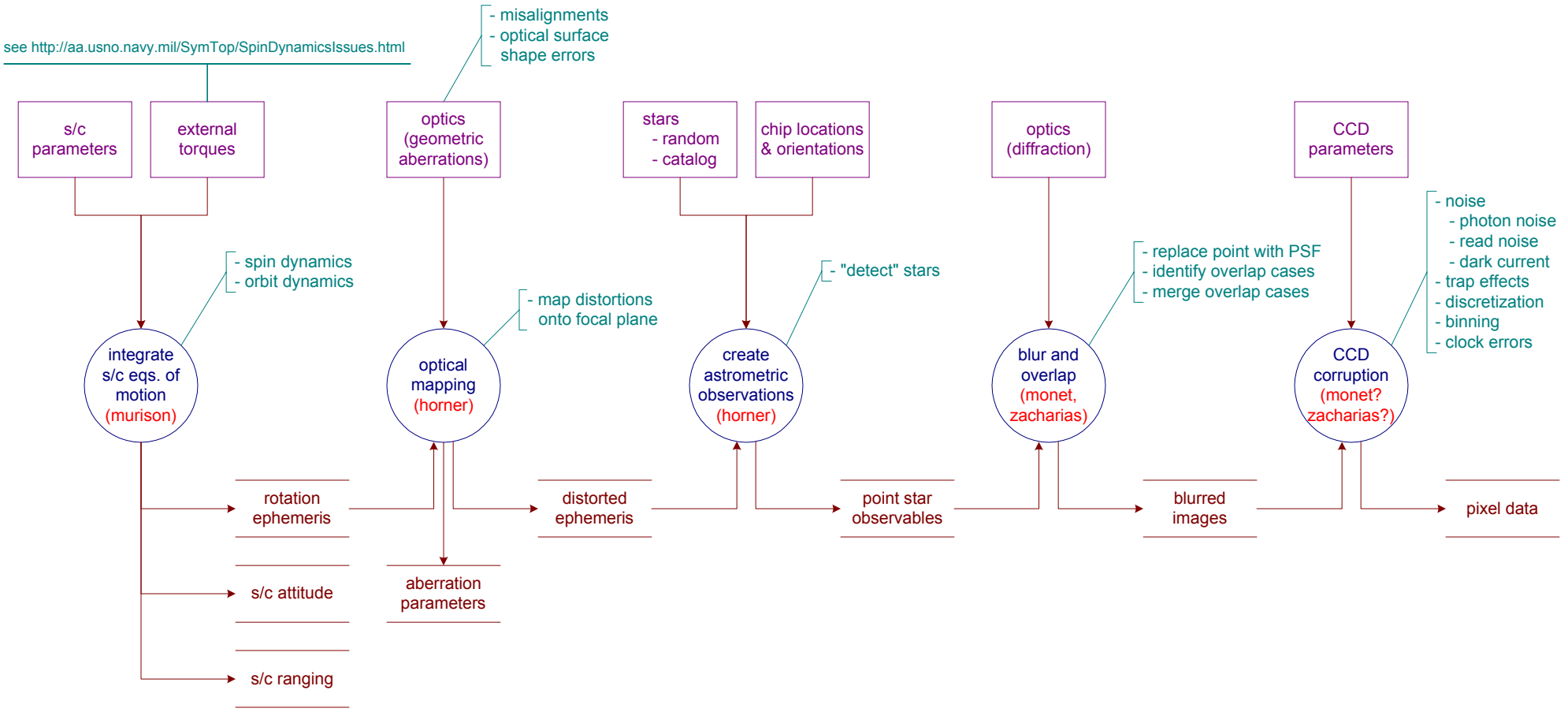

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